[Project Proposal] **Rationality and Emotion in Medical Conversations: A Probabilistic Approach to Shared Decision-Making**

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Abstract

Decision-making, particularly in high-stakes environments such as healthcare, is heavily influenced by emotional and pragmatic factors. This project investigates the dynamics of shared decision-making (SDM) in clinical settings, focusing on a medical scenario involving a patient, a doctor, and a patient's acquaintance. Long research in human psychology and cognition has shown the importance of emotions in stressful decision-making tasks. Building upon the previous works on appraisal theory and rational speech acts, we aim to develop a model of the decision-making process by integrating two theoretical frameworks: the Rational Speech Acts and the Appraisal Theory. In this way, we will make an effort to not only capture the linguistic and pragmatic aspects of the agents in an SDM scenario but to also incorporate the aspect of human emotions and observations. All of which are crucial in developing a complete model of human decision-making. The project will be centered around a case study of a rectal cancer patient deciding on post-surgery treatment options, a decision complicated by the emotional weight and potential life-changing outcomes of the choices available.

1. Introduction and Literature Review

Making decisions is not always easy, especially when choosing between multiple options that have both positive and negative elements. The ability to perform the integration of costs and benefits is crucial for resolving motivational conflicts during value-based decision-making (Glimcher and Fehr, 2013). Abnormal decision-making, including risky or irrational leading to adverse outcomes, can manifest as a symptom in neurological and neuropsychiatric disorders such as anxiety and depression (Robin and Martin, 2010). The onset of such disorders can be prompted by exposure to chronic stress (Christopher Pittenger & Ronald S Duman Pittenger and Duman, 2008), and sustained stress can lead to aberrant

decision-making (Soares et al., 2012). These results show just a small portion of the importance of emotions in specific decision-making tasks.

Past research has discovered that not only making decisions in uncertain situations, known as a cost-benefit conflict, is dramatically affected by pressure and stress but it has also been shown that when an individual perceives that the world has been harsh and unfair, they might expect that any choice they make to lead to an undesirable outcome. This individual may therefore be more likely to exploit a familiar, but nonoptimal and out-of-logic option than to explore a more suitable path (Harms, 2017; Friedman et al., 2017; Morgado et al., 2018).

Such emotional effects are especially clear in the medical domain, where the patient and everyone involved would be under significant pressure to make the optimal decision. A wrong choice might have significant effects on the direction of their life. Studies have shown the effects of family involvement in patients' medical decision-making. Many believe that family members may have divergent values and priorities from those of the patients and that their involvement could counter patients' autonomy. Moreover, the pressure from peers and hierarchical relationships within healthcare settings can affect medical errors, indicating that the decision-making environment is a critical factor in patient care (Ho, 2008). In addition, stress, whether from time constraints, professional relationships, or patient and family expectations, clearly influences the decision-making process in clinical settings, potentially leading to suboptimal outcomes (Kerstholt, 1994; Healy, 2003). Time constraints significantly impact clinical decision-making, as they may lead to rushed judgments potentially compromising patient outcomes (Van der Vegt et al., 2020).

In this project, we will work on shared decision-making (SDM). A method of care that is suitable for the care of patients. It involves a collaborative conversation seeking to respond sensibly to the problematic situation of the patient, deciding on a diagnosis approach that makes sense intellectually, practically, and emotionally. In SDM, a decision-making scenario is taken into account where some advisor(s) and a patient (decision maker) make a joint decision (Elwyn et al., 2012; Elwyn et al., 2015; Elwyn et al., 2021). Modeling a scenario to combine all these elements that influence the agents is not easy as there is a need to take both pragmatic and emotional aspects of such SDM scenarios into account. Here, we will provide a case study on a simple medical SDM scenario. In this model, a doctor, a patient, and an acquaintance of the patient are going to decide on the best approach to continue with the diagnosis of the patient. The goal of the doctor (Advisor 1) and the acquaintance (Advisor 2) is to assist the patient based on their state of mind and their understanding of the patient's preferences. The

patient would then finalize their preferred treatment approach by uttering the name of the method that maximizes their happiness. The model would consist of three main phases: one basic RSA model between the doctor (pragmatic speaker) and the acquaintance (pragmatic listener) before they are in the presence of the patient. In this model, the doctor describes the patient's situation. This model sets a prior state of mind for the acquaintance. In the second phase, we have a basic emotion appraisal model where an observer (the patient) makes an inference about the situation of the agents (the doctor and the acquaintance). This model decides on the emotional state of the patient. Finally, in the last phase of the model, a short conversation would happen between the doctor, the patient, and the acquaintance and a decision would be made on the next diagnosis step to be taken. A more detailed review of the model will be provided in the subsequent sections.

We make use of two main models in our approach: Rational Speech Acts (RSA) and Appraisal Theory (AT). The RSA framework views language use as a rational act. Speakers try to convey their message as effectively as possible, considering the listener's knowledge and the context. Listeners, in turn, try to infer the speaker's intended meaning by considering what they would say themselves in that situation. Both speakers and listeners operate under uncertainty. Speakers aren't sure exactly what the listener knows, and listeners have to consider multiple possible interpretations (Degen, 2023). The AT framework, on the other hand, suggests emotions arise from our subjective evaluation (appraisal) of situations. We don't simply react to events; we interpret them based on factors like a relevance to our goals, the potential for harm, and coping ability, and essentially, our appraisal of a situation causes an emotional, or affective, response that is going to be based on that appraisal (Houlihan et al, 2023; Campero et al, 2017; Wu et al., 2017).

For a better demonstration of the model, we work on a specific medical SDM scenario for a rectal cancer patient about the post-surgery treatment options. Colorectal cancer (CRC) is a common type of cancer that forms in the tissues of the rectum. CRC is the most common internal malignancy in men and women of Western societies and its incidence is rapidly increasing in Asia. The primary treatment for localized rectal cancer is surgical resection, where the cancerous part of the rectum is removed along with a margin of healthy tissue. After the surgical process, a proportion of those treated will relapse, predominantly with distant metastatic disease. Fifty to 60% of persons with Stage III and 25% with Stage II disease will relapse within 5 years (Desch et al., 2005). This is due to the presence of micrometastatic disease at the time of surgery. Such a disease can potentially be eradicated with the use of adjuvant therapies. This is why deciding on the suitable adjuvant therapy option after taking the advantages and

disadvantages of each possible approach is critical to keeping the cancer from returning. The post-surgery treatment options for colorectal cancer include a range of chemotherapeutic agents and targeted therapies, radiotherapy, and surveillance strategies (Compton et al., 2000).

2. Model Overview

Considering the hierarchical nature of our SDM model, we leverage Bayesian approach in probabilistic models of cognition to investigate complex cognitive processes due to their profound ability to facilitate nested inference. Significant strides in this field include elucidating pragmatic reasoning (Goodman & Frank, 2012), exploring the theory of mind (Stuhlmüller & Goodman, 2014), decoding reference games (Franke & Degen, 2016), simulating autonomous agent reasoning (Seaman et al., 2018), and appraisal theory and the intuitive theory of emotions (Houlihan et al., 2018; Ong et al., 2019; Ong et al., 2016).

Phase 1: Rational Speech Acts

The first phase is a simple RSA model. In this step, the doctor (the pragmatic speaker) and the patient's acquaintance (the pragmatic listener) have a short conversation about the situation of the patient. This conversation is assumed to happen at a time after the patient's surgery. Where the doctor might choose to discuss the results and potential next steps with the patient's acquaintance first. This allows the acquaintance to understand the situation and provide support as the patient weighs these significant lifestyle changes. In this model, the acquaintance could be either a family member or a friend of the patient who has decided to be present and assist the patient.

During this conversation, the pragmatic speaker (doctor) infers the knowledge of the pragmatic listener (the acquaintance) based on different factors. The doctor might assume the acquaintance has done prior research on post-surgery options and other details of the situation. Thus, they would have a good idea of the situation or they might have less detailed information. It might also be possible that the pragmatic listener is also a doctor. This would most likely mean that they have a good background knowledge of the situation. Taking these into account, the doctor would utter 2 words that best describe the current state of the patient. After the pragmatic listener hears the utterances of the pragmatic speaker, they would then infer the current state of the patient's state (how critical the situation is). Then, based on their inference of the patient's situation and based on their degree of closeness to the patient their emotions might be affected. Then, the acquaintance enters the patient's room along with the doctor.

Phase 2: Appraisal Theory

The second section is a simple Appraisal Theory model. As the doctor (agent 1) and the acquaintance (agent 2) enter the room, the patient (the observer) observes them. The patient would then try to infer the situation based on the look on the face of their acquaintance (such as assuring smile, red eyes, or sad face), and based on the emotions the patient infers, the patient would then try to infer the state of their disease. The Appraisal Theory model would then end with the patient's state of mind getting also affected depending on the emotion they feel from their acquaintance (the patient might get calmer or their stress and fear level might increase).

Phase 3: Bayesian SDM

Our model would then conclude with the core SDM model that combines all the results from the previous two phases into a single unified model. In this model, the doctor first decides on the best two words that describe each possible treatment based on a model from a literal listener. One utterance to describe the main disadvantage and one utterance to describe the main advantage of each possible post-surgery treatment. The patient's acquaintance hears the utterances and might decide to offer helpful advice to the patient regarding the method they find the most effective. Their decision might be affected by their emotional state. If they are trying to stay calm, they might select the option with the smallest disadvantage and higher logical advantage (this is done by their prior beliefs on different advantages and disadvantages and their prior idea of the patients' interests). On the other hand, if they are feeling overly worried and stressed, their mind might get affected accordingly and they might ignore some elements they don't usually ignore in their most rational state. The patient would then take into account the utterances from both the doctor and their acquaintance. The patient also has specific priors for the importance of each advantage and disadvantage (for example they might fear pain and want to avoid possible discomforts. Or maybe they don't care about their discomfort and they purely decide on what they infer as the most effective). These priors all get affected by their emotional state and other relevant elements. For example, the patient just had a hard surgery. This includes a possible increase in the fear of discomfort. In addition, their rational processes might be affected by the inferred emotional state of their acquaintance. In the end, the patient would decide on the treatment with the most suitable treatment (the one that maximizes their satisfaction) and utter the name of it.

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